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SOLAR/1090-78/11

Monthly Performance Report

ALBUQUERQUE WESTERN-II

NOVEMBER 1978

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT

ALBUQUERQUE WESTERN NO. 2

NOVEMBER 1978

I. SYSTEM DESCRIPTION

Albuquerque Western No. 2 is a four-story, 110-unit apartment building in Albuquerque, New Mexico. The solar energy system consists of two independently controlled systems: one system serves domestic-hot-water (DHW) preheating needs, the other serves to preheat hot water used in space heating. Only the space heating system (System II) is described in this report.

System II has an array of tracking collectors with a gross area of 6429 square feet. The array faces south at an angle of 35 degrees to the horizontal. Water is the transfer medium that delivers solar energy from the collector array to storage. Solar energy is stored underground in a 57,000-gallon concrete storage tank. During the space heating season, the heated water from storage is continuously circulated through the building to satisfy the space heating needs for each apartment. When solar energy is insufficent to satisfy the space heating load, auxiliary heating is provided by three inline gas-fired boilers. The system, shown schematically in Figure 1, has three modes of operation.

Mode 1 - Collector-to-Storage: This mode activates when the collector-to-storage pump goes on. This occurs when adequate insolation is available, based on a minimum insolation intensity. Water is pumped through the collector and circulates back to storage.

Mode 2 - Storage-to-Space Heating: This mode activates when the storage-to-space-heating circulation pump is on. This pump runs most of the time unless storage is bypassed during maintenance or emergencies.

Mode 3 - Auxiliary Space Heating: This mode activates when the natural gas-fired boiler system (3 boilers in parallel operation) is required to "top out" the continuously circulating hot water in the space heating system in order to obtain a manually-selected temperature level. This occurs when the solar energy system can no longer meet the preset temperature.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied during the month of November and the solar energy system operated continuously during the month. Solar energy satisfied 39 percent of the space heating requirements. The solar energy system provided a fossil fuel energy savings of 87.8 million Btu and incurred an electrical energy expense of 8.7 million Btu.

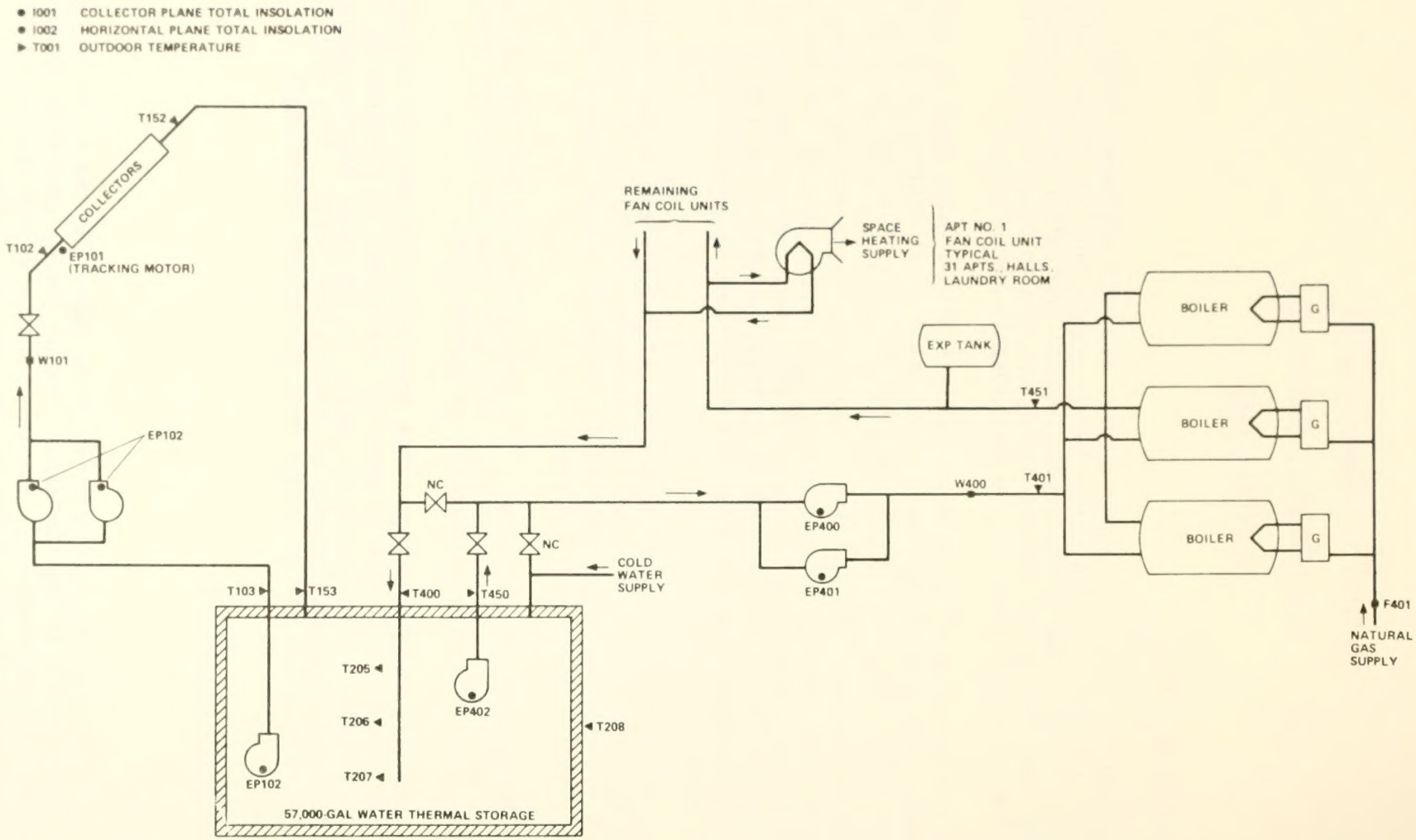

Figure 1. ALBUQUERQUE WESTERN NO. 2 SOLAR ENERGY SYSTEM SCHEMATIC

Because of the high flow rate in the storage to space heating loop, temperature measurements in this loop do not provide the resolution necessary to evaluate energy balance. The auxiliary energy contribution was estimated based on the fossil fuel consumed; the solar energy contribution was computed as the space heating load minus the auxiliary energy contribution. Storage performance was not evaluated because the amount of water actually in storage during the month was not known.

WEATHER CONDITIONS

During the month total incident solar energy on the collector array was 203.0 million Btu for a daily average of 1052 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during November of 1839 Btu per square foot for a south-facing plane with a tilt of 35 degrees to the horizontal. The average ambient temperature during November was 47°F as compared with the long-term average for November of 45°F.

THERMAL PERFORMANCE

Collector - The total incident solar radiation on the collector array for the month of November was 203.0 million Btu. During the period the collector loop was operating the total insolation amounted to 142.0 million Btu. The total collected solar energy for the month of November was 43.7 million Btu, resulting in a collector array efficiency of 22 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 43.7 million Btu. Operating energy required by the collector loop was 3.8 million Btu.

Storage - Solar energy delivered to storage was 43.7 million Btu. There were 52.7 million Btu delivered from storage to the space heating subsystem. The average storage temperature for the month was 119°F.

Space Heating Load - The space heating subsystem consumed 52.7 million Btu of solar energy and 81.5 million Btu of auxiliary thermal energy (equivalent to 135.8 million Btu of fossil fuel energy) to satisfy a space heating load of 134.3 million Btu. The solar fraction of this load was 39 percent. The space heating subsystem consumed a total of 18.3 million Btu of operating energy, resulting in an electrical energy expense of 8.7 million Btu.

OBSERVATIONS

The collected solar energy was set equal to the energy delivered to storage, because of sensor resolution problems in the collector to storage loop. However, the error introduced by this assumption is believed small (less than 10 percent) due to very high flow rate in the loop. The problem is under investigation by IBM/Boeing.

Because of the unknown quantity of water actually in the storage tank, storage performance was not evaluated.

ENERGY SAVINGS

The solar energy system provided a total fossil fuel energy savings of 87.8 million Btu. The space heating subsystem incurred an electrical energy expense of 8.7 million Btu.

III. ACTION STATUS

IBM and Boeing are investigating the temperature resolution problem.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/11
REPORT PERIOD: NOVEMBER,1978

SITE/SYSTEM DESCRIPTION:
THE SOLAR SYSTEM FOR THE ALBUQUERQUE WESTERN SITE PROVIDES FOR DOMESTIC HOT WATER (DHW) PREHEATING AND FOR SOLAR ASSISTED HOT WATER SPACE HEATING. THE SITE IS A 4 STORY, 110 UNIT HOUSING COMPLEX FOR THE ELDERLY AND HANDICAPPED. THE SITE'S SOLAR SYSTEM IS IN ACTUALITY, TWO SEPARATE SOLAR SYSTEMS; EACH SYSTEM HAVING ITS OWN COLLECTORS, STORAGE, OPERATING MODES AND CIRCULATION LOOPS. THE SYSTEMS OPERATE INDEPENDENTLY; ONE FOR DHW AND THE OTHER FOR SPACE HEATING NEEDS.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	202.969 MILLION BTU
	31571 BTU/SQ.FT.
COLLECTED SOLAR ENERGY	43.698 MILLION BTU
	6797 BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	47 DEGREES F
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.26
ECSS OPERATING ENERGY	3.818 MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	22.121 MILLION BTU
TOTAL ENERGY CONSUMED	201.625 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	134.260	N.A.	134.260 MILLION BTU
SOLAR FRACTION	N.A.	39	N.A.	39 PERCENT
SOLAR ENERGY USED	N.A.	52.696	N.A.	52.696 MILLION BTU
OPERATING ENERGY	N.A.	18.302	N.A.	22.121 MILLION BTU
AUX. THERMAL ENERGY	N.A.	81.483	N.A.	81.483 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
AUX. FOSSIL FUEL	N.A.	135.806	N.A.	135.806 MILLION BTU
ELECTRICAL SAVINGS	N.A.	-8.730	N.A.	-8.730 MILLION BTU
FOSSIL SAVINGS	N.A.	87.826	N.A.	87.826 MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.641

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/11
REPORT PERIOD: NOVEMBER,1978

SITE/SYSTEM DESCRIPTION:
THE SOLAR SYSTEM FOR THE ALBUQUERQUE WESTERN SITE PROVIDES FOR DOMESTIC HOT WATER (DHW) PREHEATING AND FOR SOLAR ASSISTED HOT WATER SPACE HEATING. THE SITE IS A 4 STORY, 110 UNIT HOUSING COMPLEX FOR THE ELDERLY AND HANDICAPPED. THE SITE'S SOLAR SYSTEM IS IN ACTUALITY, TWO SEPARATE SOLAR SYSTEMS; EACH SYSTEM HAVING ITS OWN COLLECTORS, STORAGE, OPERATING MODES AND CIRCULATION LOOPS. THE SYSTEMS OPERATE INDEPENDENTLY; ONE FOR DHW AND THE OTHER FOR SPACE HEATING NEEDS.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	214.132 GIGA JOULES
	358518 KJ/SQ.M.
COLLECTED SOLAR ENERGY	46.101 GIGA JOULES
	77186 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	8 DEGREES C
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.26
ECSS OPERATING ENERGY	4.028 GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	23.338 GIGA JOULES
TOTAL ENERGY CONSUMED	212.714 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	141.644	N.A.	141.644 GIGA JOULES
SOLAR FRACTION	N.A.	39	N.A.	39 PERCENT
SOLAR ENERGY USED	N.A.	55.594	N.A.	55.594 GIGA JOULES
OPERATING ENERGY	N.A.	19.309	N.A.	23.338 GIGA JOULES
AUX. THERMAL ENG	N.A.	85.965	N.A.	85.965 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. FOSSIL FUEL	N.A.	143.275	N.A.	143.275 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	-9.210	N.A.	-9.210 GIGA JOULES
FOSSIL SAVINGS	N.A.	92.656	N.A.	92.656 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.641

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REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM
REPORT PERIOD: NOVEMBER,1978

SOLAR/1090-78/11

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	*	*	*	N	*	N	*
2	8.527	57	0.643	O	0.159	O	0.075
3	3.476	51	1.471	T	0.049	T	0.423
4	4.597	53	1.081		0.052		0.235
5	9.416	53	1.028	A	0.195	A	0.109
6	9.533	53	1.462	P	0.180	P	0.153
7	10.564	52	2.044	P	0.205	P	0.193
8	10.480	53	2.287	L	0.207	L	0.218
9	10.169	56	2.077	I	0.203	I	0.204
10	4.427	54	1.793	C	0.050	C	0.405
11	5.839	48	2.535	A	0.083	A	0.434
12	3.892	52	2.358	B	0.028	B	0.606
13	8.616	45	1.288	L	0.167	L	0.149
14	4.970	44	1.499	E	0.069	E	0.302
15	8.373	40	2.400		0.150		0.287
16	5.610	39	1.749		0.070		0.312
17	10.068	41	1.845		0.243		0.183
18	9.770	41	2.094		0.234		0.214
19	9.995	43	2.471		0.245		0.247
20	8.843	46	2.391		0.245		0.270
21	0.893	45	1.758		0.007		1.969
22	2.906	51	1.186		0.010		0.408
23	3.166	50	0.421		0.011		0.133
24	0.791	48	0.708		0.007		0.895
25	8.139	47	0.825		0.151		0.101
26	3.892	40	1.834		0.025		0.471
27	6.542	37	2.208		0.138		0.338
28	7.460	37	2.309		0.157		0.310
29	6.514	41	2.544		0.144		0.391
30	8.737	43	2.631		0.206		0.301
SUM	202.969	-	52.696	N.A.	3.818	N.A.	-
AVG	6.766	47	1.757	N.A.	0.127	N.A.	0.260
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/11
REPORT PERIOD: NOVEMBER,1978

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	*	*	*	*	*
2	8.527	6.763	2.019	63	0.237
3	3.476	2.280	0.514	52	0.148
4	4.597	2.101	0.388	58	0.085
5	9.416	8.192	2.939	59	0.312
6	9.533	7.714	2.450	59	0.257
7	10.564	9.078	3.205	57	0.303
8	10.480	9.065	3.312	62	0.316
9	10.169	8.761	3.032	63	0.298
10	4.427	1.523	-0.013	60	-0.003
11	5.839	3.443	0.589	49	0.101
12	3.892	0.562	-0.027	56	-0.007
13	8.616	6.567	1.992	52	0.231
14	4.970	2.210	0.456	50	0.092
15	8.373	6.563	2.061	48	0.246
16	5.610	2.091	0.441	*	0.079
17	10.068	8.436	3.088	47	0.307
18	9.770	8.358	3.148	*	0.322
19	9.995	8.433	3.146	53	0.315
20	8.843	7.623	2.368	55	0.268
21	0.893	0.000	0.000	48	0.000
22	2.906	0.482	-0.032	55	-0.011
23	3.166	0.000	0.000	54	0.000
24	0.791	0.000	0.000	49	0.000
25	8.139	5.596	1.687	52	0.207
26	3.892	0.605	-0.025	43	-0.006
27	6.542	4.397	1.036	39	0.158
28	7.460	5.352	1.426	42	0.191
29	6.514	4.346	0.900	47	0.138
30	8.737	6.739	2.141	50	0.245
SUM	202.969	142.015	43.698	-	-
AVG	6.766	4.734	1.457	53	0.215
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/11
REPORT PERIOD: NOVEMBER,1978

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	*	*	*	*	*
2	2.019	0.643	1.416	120	1.020
3	0.514	1.471	-1.755	120	-0.554
4	0.388	1.081	-0.801	116	0.721
5	2.939	1.028	2.341	119	1.147
6	2.450	1.462	0.800	123	0.923
7	3.205	2.044	1.045	124	0.964
8	3.312	2.287	0.892	126	0.960
9	3.032	2.077	0.553	128	0.867
10	-0.013	1.793	-3.044	125	95.719
11	0.589	2.535	-2.587	119	-0.088
12	-0.027	2.358	-2.282	113	-2.776
13	1.992	1.288	1.852	113	1.576
14	0.456	1.499	-1.110	114	0.853
15	2.061	2.400	0.802	114	1.554
16	0.441	1.749	0.034	114	4.043
17	3.088	1.845	2.773	118	1.496
18	3.148	2.094	1.785	123	1.232
19	3.146	2.471	1.076	126	1.127
20	2.368	2.391	-0.430	126	0.828
21	0.000	1.758	-2.308	123	1.000
22	-0.032	1.186	-1.293	119	3.324
23	0.000	0.421	-0.185	118	1.000
24	0.000	0.708	-0.678	117	1.000
25	1.687	0.825	1.479	118	1.366
26	-0.025	1.834	-1.572	117	-10.591
27	1.036	2.208	-0.308	116	1.834
28	1.426	2.309	0.586	116	2.030
29	0.900	2.544	-0.802	115	1.935
30	2.141	2.631	0.863	116	1.632
SUM	43.698	52.696	-0.889	-	-
AVG	1.457	1.757	-0.030	119	1.186
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/11
REPORT PERIOD: NOVEMBER,1978

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	*	*	*	*	*	N	*	*	*	N	*
2	2.005	32	0.643	0.610	1.362	C	2.270	-0.323	1.072	O	57
3	3.077	48	1.471	0.610	1.606	T	2.676	-0.213	2.451	T	51
4	3.294	33	1.081	0.610	2.212		3.687	-0.216	1.802		53
5	2.873	36	1.028	0.610	1.845	A	3.074	-0.359	1.714	A	53
6	2.624	56	1.462	0.610	1.162	P	1.937	-0.344	2.436	P	53
7	3.111	66	2.044	0.610	1.067	P	1.778	-0.369	3.407	P	52
8	3.289	70	2.287	0.610	1.002	L	1.670	-0.371	3.812	L	53
9	2.687	77	2.077	0.609	0.609	I	1.015	-0.367	3.462	I	56
10	2.683	67	1.793	0.610	0.881	C	1.468	-0.214	2.988	C	54
11	4.510	56	2.535	0.610	1.975	A	3.292	-0.247	4.226	A	48
12	5.173	46	2.358	0.610	2.815	B	4.691	-0.191	3.930	B	52
13	4.473	29	1.288	0.611	3.185	L	5.308	-0.331	2.146	L	45
14	4.442	34	1.499	0.611	2.943	E	4.905	-0.233	2.499	E	44
15	5.623	43	2.400	0.611	3.223		5.372	-0.314	4.000		40
16	5.540	32	1.749	0.612	3.791		6.318	-0.234	2.915		39
17	5.833	32	1.845	0.611	3.988		6.646	-0.407	3.076		41
18	5.537	38	2.094	0.610	3.444		5.739	-0.398	3.489		41
19	5.505	45	2.471	0.610	3.035		5.058	-0.409	4.118		43
20	5.151	46	2.391	0.610	2.760		4.601	-0.409	3.984		46
21	4.675	38	1.758	0.610	2.917		4.862	-0.171	2.930		45
22	4.067	29	1.186	0.604	2.881		4.802	-0.171	1.977		51
23	3.441	12	0.421	0.610	3.019		5.032	-0.175	0.702		50
24	3.986	18	0.708	0.611	3.278		5.463	-0.171	1.180		48
25	3.907	21	0.825	0.610	3.082		5.136	-0.315	1.375		47
26	5.717	32	1.834	0.610	3.814		6.357	-0.189	3.056		40
27	6.452	34	2.208	0.611	4.243		7.072	-0.301	3.681		37
28	6.754	34	2.309	0.611	4.445		7.409	-0.321	3.848		37
29	6.878	37	2.544	0.611	4.334		7.225	-0.308	4.240		41
30	6.480	41	2.631	0.610	3.849		6.415	-0.370	4.385		43
SUM	134.260	-	52.696	18.302	81.483	N.A.	135.806	-8.730	97.826	-	-
AVG	4.475	39	1.757	0.610	2.716	N.A.	4.527	-0.291	2.928	N.A.	47
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N40-	N113

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/11
REPORT PERIOD: NOVEMBER,1978

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	*	N	*	*	N	N	N
2	1326	O	57	63	O	O	O
3	541	T	51	52	T	T	T
4	715		53	58			
5	1465	A	53	59	A	A	A
6	1483	P	53	59	P	P	P
7	1543	P	52	57	P	P	P
8	1630	L	53	62	L	L	L
9	1582	I	56	63	I	I	I
10	639	C	54	60	C	C	C
11	908	A	48	49	A	A	A
12	605	B	52	56	B	B	B
13	1340	L	45	52	L	L	L
14	773	E	44	50	E	E	E
15	1302		40	48			
16	873		39	*			
17	1566		41	47			
18	1520		41	*			
19	1555		43	53			
20	1376		46	55			
21	139		45	48			
22	452		51	55			
23	492		50	54			
24	133		48	49			
25	1266		47	52			
26	605		40	43			
27	1018		37	39			
28	1160		37	42			
29	1013		41	47			
30	1359		43	50			
SUM	31571	N.A.	-	-	-	-	-
AVG	1052	N.A.	47	53	N.A.	N.A.	N.A.
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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